The Mathematics of the Public Holidays of Singapore

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Adam Schall (汤若望 [湯若望], Tāng Ruòwàng, 1592-1666)
Public Holidays in Singapore

► There are 11 public holidays in Singapore. Three of them are secular.

1. New Year’s Day
2. Labor Day
3. National Day

Cultural, Racial or Religious Holidays

► The remaining eight cultural, racial or religious holidays consist of two Chinese, two Muslim, two Indian and two Christian.

1. Chinese New Year and 2nd day of CNY
2. Good Friday (Easter Sunday is a day off anyway!)
3. Vesak Day (Buddha’s birthday)
4. Deepavali
5. Christmas Day
6. Eid ul-Fitr (Hari Raya Puasa), the end of Ramadan
7. Eid ul-Adha (Hari Raya Haji)

► Christmas Day falls on a fixed date, but all the others move.

► The Muslim holidays move throughout the year, while the others move within a one month interval.
The Earth revolves counterclockwise around the Sun in an elliptical orbit. The Earth rotates counterclockwise around an axis that is tilted 23.5 degrees.

In the northern hemisphere, the day will be longest at the June solstice and shortest at the December solstice. At the two equinoxes day and night will be equally long. The equinoxes and solstices are called the seasonal markers.

The Shadow of a Gnomon

A gnomon is a vertical rod. At the equinoxes, the path of the shadow cast by a gnomon will be a straight line. The rest of the year, the path will be a hyperbola.

On the northern hemisphere, the noon shadow will be shortest at June solstice and longest at December solstice.
The Year and the Month

- The tropical year (or solar year) is the time from one March equinox to the next. The mean value is $365.2422$ days.
- The synodic month is the time from one new Moon to the next. It ranges from 29.27 days to 29.84 days with a mean of 29.53 days.
- $12 \times 29.5 = 354$, so a lunar year consisting of 12 lunar months is about 11 days short of a solar year

$$365 - 12 \times 29.5 = 11.$$  

$$365/11 \approx 33.$$  

The Metonic Cycle

- 19 solar years is almost exactly $235 = 19 \times 12 + 7$, lunar months.

$$235 \times 29.53 = 6939.6884,$$
$$19 \times 365.2422 = 6939.6018.$$  

The difference is about two hours.

- This is called the Metonic cycle (432 BCE). It was known in China by about 600 BCE and was called the zhāng (章) cycle.
- The Metonic cycle is used in the Jewish calendar, in the computation of Easter, and was used in the Chinese calendar before 104 BCE.
Classification of Calendars

**solar**  Gregorian calendar. Basic unit is day. Approximates the tropical year by adding leap days. Ignores the Moon. The year is 365 or 366 days.

**lunar**  Islamic calendar. Basic unit is lunar month. Ignores the Sun. The year is 12 months or 354 (sometimes 353 or 355) days.

**lunisolar**  Chinese and Jewish calendars. Basic unit is lunar month. Approximates the tropical year by adding leap months. The year is 12 or 13 months. A 12-month year is 354 (sometimes 353 or 355) days. A 13-month year is 384 (sometimes 383 or 385) days.

- The Chinese calendar is NOT a lunar calendar!

Alternative Classification of Calendars

- **Arithmetical**: Gregorian and Jewish calendars. Based on arithmetical formulas. Prediction and conversion between different arithmetical calendars is simple.
- **Astronomical**: Islamic, Indian and Chinese calendars. Based on astronomical data. Prediction and conversion is hard.
The Roman Calendar

- The Roman year started on March 1. That’s still reflected in the names September, October, November and December.
- February 29 would then be the last day of the year.

The Gregorian Calendar

- A normal year consists of 365 days, but leap years have 366 days. Year $n$ is a leap year if $n$ is divisible by 4, but not by 100 or if $n$ is divisible by 400. 1900 is not a leap year, but 2000 is.
- The average length of the Gregorian year is 365.2425. The difference between this and the tropical year will cause an error of about one day in 2,500 years.
The Julian Calendar

- The Julian Calendar was implemented by Julius Caesar.
- In the Julian calendar, every fourth year is a leap year.
- Pope Gregory XIII introduced the Gregorian calendar in 1582.
- 4 October 1582 was followed by 15 October 1582.
- In the UK, 2 Sep 1752 was followed by 14 Sep 1752.
- Russia changed after the revolution in 1917. They had to skip 13 days.
Computation of Easter

- The rule of thumb is that Easter Sunday is the first Sunday after the first full Moon on or after the day of the March equinox.
- The actual rule is that Easter Sunday falls on the first Sunday after the first ecclesiastical full Moon on or after March 21. The ecclesiastical full Moon is an approximation to the real full Moon used by the Church and the first one after March 21 is called the Paschal full Moon. Each year it will move either 10 or 11 days earlier, or 18 or 19 days later.
- It will fall between March 22 and April 25. In order to derive the latest date, you need to know that the Paschal full Moon is always 29 days after the previous ecclesiastical full Moon.

The Actual Computation of Easter

If you study the rules for the ecclesiastical Moon, you can show that Easter Sunday in year $y$ falls on day $d$ in month $m$ where $d$ and $m$ are computed as follows (all remainders from division are dropped).

\[
\begin{align*}
  c &= \frac{y}{100} \\
  n &= y - 19 \times \lfloor \frac{y}{19} \rfloor \\
  k &= \lfloor (c - 17)/25 \rfloor \\
  i &= c - c/4 - \lfloor (c - k)/3 \rfloor + 19 \times n + 15 \\
  j &= i - 30 \times \lfloor i/30 \rfloor \\
  j &= i - \lfloor i/28 \rfloor \times (1 - \lfloor i/28 \rfloor \times [29/(i + 1)]) \\
  j &= j - 7 \times \lfloor j/7 \rfloor \\
  l &= i - j \\
  m &= 3 + \lfloor (l + 40)/44 \rfloor \\
  d &= l + 28 - 31 \times \lfloor m/4 \rfloor 
\end{align*}
\]
More about Easter

► If the date of Easter Sunday is $X$ in a certain year, what are the possible dates that it can fall on in the following year?

► First observe that $365 = 52 \times 7 + 1$, so if the next year is an ordinary year, then $X$ will be a Monday, and if it is a leap year it will be Tuesday.

► The Paschal Moon is between $X - 7$ and $X - 1$, so the following year there will be a full Moon some time between $X - 18$ and $X - 11$. If that is on or after March 21, then that will be the Paschal Moon. If the following year is a normal year, then $X - 1$ is a Sunday, in which case Easter Sunday will be $X - 15$ or $X - 8$. If the following year is a leap year, then $X - 2$ is a Sunday, in which case Easter Sunday will be $X - 16$ or $X - 9$.

More about Easter

► If the full Moon between $X - 18$ and $X - 11$ is before March 21, we must instead add 18 or 19 days to the full Moon between $X - 7$ and $X - 1$, which takes us to some time between $X + 11$ and $X + 18$. If the following year is a normal year, then $X - 1$ is a Sunday, in which case Easter Sunday will be $X + 13$ or $X + 20$. If the following year is a leap year, then $X - 2$ is a Sunday, in which case Easter Sunday will be $X + 12$ or $X + 19$. 
Christian Solar Holidays

- Annunciation Day (Lady Day), March 25, nine months before Christmas, used to mark the start of the year until 1752 in the UK
- Walpurgis Night, April 30 or May Day, May 1
- Midsummer Day, June 24, birth of John the Baptist
- Lammas (loaf-mass day), August 1, the festival of the first wheat harvest of the year
- Michaelmas, September 29, named after the Archangel Michael
- All Saints’ Day (All Hallows), November 1 or Halloween on the night of October 31
- Christmas, December 25
- Candlemas, February 2, presentation of Jesus at the Temple forty days after Christmas, Groundhog Day
- These form the four quarter days (solstices and equinoxes) and the four cross-quarter days (halfway between)

The Twelve Days of Christmas

Epiphany on January 6 marks the end of the twelve days of Christmas. Some traditions treat it as the twelfth day itself, some as the thirteenth day.
Christian Lunar Holidays

- Lent, forty days of fast before Easter, but also including Sundays, so it starts on Ash Wednesday in the seventh week before Easter
- Ascension Thursday, the fortieth day after Easter Sunday, counted inclusively
- Pentecost, the fiftieth day after Easter Sunday, counted inclusively

Buddha’s Birthday (Vesak Day)

- Traditionally, Buddhists have observed Buddha’s Birthday (Vesak Day) on the 8th or 15th day of the fourth month.
- Since the 1950s the Singapore Buddhist Federation celebrates it on the first full Moon in May.
Indian Calendars

- There are three main types of calendars in India.
- Solar calendars (following the sidereal, not the tropical year).
- Lunisolar calendars that end with the new Moon (amanta), mostly used in southern India.
- Lunisolar calendars that end with the full Moon (purnimanta), mostly used in northern India.
- Notice that in Indian lunisolar calendars, the day of the new (full) Moon is the last day of the month, not the first as in the Chinese calendar.
- Since they follow the sidereal years, solar based Indian new years drift in the Gregorian calendars. New years around April 14 were intended to mark the vernal equinox.
- Indian days start with sunrise.

Deepavali

- Diwali, known as Deepavali in southern India, is a national public holiday in India, Sri Lanka, Nepal, Mauritius, Malaysia and Singapore.
- The holiday in Sri Lanka, Malaysia and Singapore usually falls one day earlier than the holiday in India and Mauritius. In Nepal both days are public holidays.
- In India there are both national and state public holidays.
- It can be shown that Deepavali will fall between Oct 15 and Nov 15.
Deepavali 2

- Deepavali is part of a four-day holiday season.
- Naraka Chaturdasi (the day before the new Moon) is celebrated as a state holiday in Tamil Nadu, Kerala and Puducherry. I will refer to this as Deepavali.
- The next day Lakshmi Puja (the day of the new Moon or Amavasya) is celebrated as a national public holiday. I will refer to this as Diwali.
- The next day Govardhan Puja is celebrated as a state holiday and New Year Day in Gujarat and Karnataka.
- The next day Bhai Duj (Bhai Dooj) is celebrated as a state holiday in Uttar Pradesh and Uttarakhand.

Tithi

- In order to understand the Indian lunisolar calendar, we must understand tithi. Tithi is a lunar day, or the time it takes for the longitudinal angle between the moon and the sun to increase by 12°.
- There are 30 tithis in each lunar month, and they vary from approximately 19 to approximately 26 hours.
- The day gets its name from the name of the tithi at the time of sunrise.
- Since a tithi can be more than 24 hours, there will sometimes be a tithi that contains two sunrises. In that case we will get a repeated day.
- Since a tithi can be less that 24 hours, there will sometimes be a tithi that contains no sunrise. In that case we will skip a day.
Deepavali Details

- The second to last tithi before the new Moon is called Chaturdasi and the tithi ending at the new Moon is called Amavasya.
- Notice that the new Moon will occur during the Amavasya day, unless the Amavasya day is skipped.
- In southern India Deepavali is celebrated on Chaturdasi day (29) in the month of Asvina. (If there is an added Chaturdasi day it falls on the second Chaturdasi day, and if the Chaturdasi day is skipped it falls on the Amavasya day.)
- In northern India Diwali is celebrated on Amavasya.
- However, in northern India, some of the Deepavali ceremonies are supposed to be done during a time period called Pradosha. It is the first 2/15 of the night, or about the first 1.5 hours after sunset.

Northern Deepavali 1

- There are four cases to consider for northern Deepavali.

<table>
<thead>
<tr>
<th>Sunrise, start of Pradosha 1</th>
<th>Sunrise, end of Pradosha 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amavasya day</td>
<td>Amavasya day</td>
</tr>
</tbody>
</table>

- Suppose the Amavasya tithi contains one Pradosha, which falls during the Amavasya day. In that case Deepavali is celebrated during Pradosha 2, which will be both during the Amavasya day and the Amavasya tithi.
Suppose the Amavasya tithi contains one Pradosha, which falls during the day Chaturdasi day. (I leave it as an exercise to the reader to check that in this case there cannot be a skipped Chaturdasi.) In that case Deepavali is celebrated during Pradosha 1, which will coincide with the Tamil holiday on Chaturdasi.

If the Amavasya tithi contains two Pradoshas, there are different conventions according to Chatterjee, but my impression is that most Indians would pick Pradosha 2, since that would be both during the Amavasya tithi and the Amavasya day.
If the Amavasya tithi contains no Pradosha, I do not know what the convention is, but my impression is that most Indians would pick Pradosha 2, since that at least falls during the Amavasya day. (It cannot both be no Amavasya day and no Pradosha in the Amavasya tithi.)

The Islamic Calendar

- No leap months. Muslim holidays move about 11 days earlier each year.
- New months are determined by the first sighting of the waxing crescent. A waxing Moon is normally not visible until it is more than 24 hours old.
- The first day of the Muslim month is usually the third day of the Chinese or Jewish month.
The Islamic Holidays

- Strictly speaking, the Muslim day starts at sunset the previous day, but when converting dates, we usually ignore the first part of the Muslim day.

- Eid ul-Fitr (Hari Raya Puasa), the end of Ramadan, is the first day of the 10th month. Eid ul-Adha (Hari Raya Haji) is the 10th day of the 12th month.

- In 2000 the end of Ramadan fell on Jan 8 and on Dec 27. Since $365/11 \approx 33$, we see that such double Eids will occur every 32 or 33 years.

Lunar Visibility Chart
Lunar Visibility Theory

Muslim Calendar in Singapore
Before 1974, the Muslim calendar in Singapore was based on sightings from Sultan Shoal, the southernmost part of Singapore. MUIS (Majlis Ugama Islam Singapura), the Islamic Religious Council of Singapore, then decided that the new month starts if the Moon is above the horizon at sunset on the eve of the 29th day.

In the 80s they decided to require that the altitude of the Moon should be more than 5 degrees at sunset.

In the 90s they switched to 2 degrees. This was part of an attempt to coordinate the major holidays with Malaysia, Brunei and Indonesia, called the MABIMS criteria.
MABIMS Criteria

- The altitude of the Moon at sunset is more than 2 degrees.
- The distance between the Sun and the Moon at sunset is more than 3 degrees.
- The age of the Moon at sunset is more than 8 hours.
- In practice, however, MUIS only looks at the first of the criteria.
- The minimum possible values of the three variables in the MABIMS criteria are approximately:
  - Altitude > 6°
  - Distance > 7°
  - Age > 16 h

The Islamic Calendar in Various Countries

- In spite of the difficulties, some Muslim communities base their calendar on actual Moon sightings. This is done in India, Pakistan, Bangladesh and the US.
- In Saudi Arabia and most of the Gulf countries they have simplified the calendar. They start the lunar month if the Moon sets after the Sun on the 29th day of the previous month, as seen from Mecca.
Some sources describe an arithmetical Islamic calendar. It is sometimes used for approximate conversions for civil purposes, but is not used for religious purposes by Sunnis or Twelver Shi’ites (Ithna Asharia).

However, it is common among Sevener Shi’ites (Isma’ili), including the Bohras (Musta’lis) and Nizaris (Isma’ili Khojas, Aga Khanis).

There are currently about one million Bohras and about 15 million Nizaris, compared to over a billion Sunnis and close to a hundred million Twelver Shi’ites.

The average lunar year is about 354 11/30 days, so you get a reasonable lunar calendar by using a cycle of 11 leap years (kasibah) with 355 days in a 30 year cycle. The odd numbered months have 30 days and the even numbered months have 29 days, except in a leap year when the 12th and final month has 30 days.

There are several versions for how to space out the 11 leap years. The most common rule is the one followed by the Nizaris Isma’ili, which uses years 2, 5, 7, 10, 13, 16, 18, 21, 24, 26, 29, but some replace 16 by 15 and the Bohras replace 7 by 8, 18 by 19 and 26 by 27.
The Chinese Calendar

The goal is to approximate the solar year by adding leap months. Since 12 lunar months are 11 days too short we will need to add a leap month a little bit more than every third year.

In ancient times, this was done by observing nature.

Since $235 = 19 \times 12 + 7$, we can use the Metonic cycle and get a decent lunisolar calendar by having 7 leap years in every 19-year cycle.

Chinese New Year

It can be shown that Chinese New Year will always fall between Jan 21 and Feb 21.

Most of the time Chinese New Year will fall 11 (or 10 or 12) days earlier than the previous year, but if that would take us outside of the Chinese New Year range of Jan 21 to Feb 21, we must add a leap month, so Chinese New Year jumps 19 (or 18 or 20) days later.

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
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<th>2006</th>
<th>2007</th>
<th>2008</th>
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</tr>
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<tr>
<td>Jan 22</td>
<td></td>
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</tr>
<tr>
<td>Feb 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>11</td>
<td>20</td>
<td>11</td>
<td>12</td>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
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<tbody>
<tr>
<td>Feb 14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>11</td>
<td>18</td>
<td>10</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>
Chinese New Year and the End of Ramadan

- The Muslim holidays will always fall about 11 days earlier.
- Sometimes the End of Ramadan will coincide with Chinese New Year. They will then stay together for two or three years. After that, Ramadan will continue on its 33 year cycle through the calendar, while CNY will jump later because of a leap month.
- They will then meet up again in 30 or 31 years. This happened from 1964 to 1966, from 1996 to 1998, and will happen again from 2029 to 2031.
Because of the Metonic cycle, there is almost a 19-year cycle in the Chinese calendar.

I was born on April 16, 1960. This was the 21st day in the 3rd month in the Chinese calendar. Normally my birthday will fall on different days in the Chinese calendar, but my 19th birthday fell on the 20th day in the third month. The same goes for my 38th and 57th birthday. So we see that the 19-year cycle is close but not exact.

There are two reasons for this. First of all, the Metonic cycle is off by about two hours.

But more importantly, we are now comparing the Chinese calendar not with the tropical year, but with the Gregorian calendar, which is just an approximation to the tropical year. In particular, since 19 is not a multiple of 4, different cycles will contain different numbers of leap years.
The 24 Jiéqì

A fundamental concept in the Chinese calendar is the 24 solar terms or jiéqì (节气). They are a generalization of the solstices and equinoxes. The even ones are called major solar terms or zhōngqì (中气).
### List of the 24 Jiéqì

<table>
<thead>
<tr>
<th>Jiéqì (Chinese)</th>
<th>English (Translation)</th>
<th>Month</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1 Lìchūn</td>
<td>Beginning of spring</td>
<td>February</td>
<td>April 4</td>
</tr>
<tr>
<td>Z1 Yúshuǐ</td>
<td>Rain water</td>
<td>February</td>
<td>March 19</td>
</tr>
<tr>
<td>J2 Jǐngzhè</td>
<td>Waking of insects</td>
<td>March</td>
<td>June 6</td>
</tr>
<tr>
<td>Z2 Chūnfēn</td>
<td>March equinox</td>
<td>March</td>
<td>May 6</td>
</tr>
<tr>
<td>J3 Qīngmíng</td>
<td>Pure brightness</td>
<td>April</td>
<td>May 5</td>
</tr>
<tr>
<td>Z3 Gǔyǔ (or Gǔyù)</td>
<td>Grain rain</td>
<td>April</td>
<td>May 20</td>
</tr>
<tr>
<td>J4 Lìxià</td>
<td>Beginning of summer</td>
<td>May</td>
<td>June 6</td>
</tr>
<tr>
<td>Z4 Xuàomán</td>
<td>Grain full</td>
<td>May</td>
<td>June 21</td>
</tr>
<tr>
<td>J5 Mángzhòng (or Mángzhòng)</td>
<td>Grain in ear</td>
<td>June</td>
<td>July 6</td>
</tr>
<tr>
<td>J6 Xuàoshū</td>
<td>Slight heat</td>
<td>June</td>
<td>July 7</td>
</tr>
<tr>
<td>Z5 Xiàzhì</td>
<td>Great heat</td>
<td>July</td>
<td>July 23</td>
</tr>
<tr>
<td>J7 Lìqì</td>
<td>Beginning of autumn</td>
<td>August</td>
<td>August 8</td>
</tr>
<tr>
<td>Z6 Chūnsūn</td>
<td>Limit of heat</td>
<td>August</td>
<td>August 23</td>
</tr>
<tr>
<td>J8 Bāilù</td>
<td>White dew</td>
<td>September</td>
<td>September 8</td>
</tr>
<tr>
<td>Z7 Qiūfèn</td>
<td>September equinox</td>
<td>September</td>
<td>September 23</td>
</tr>
<tr>
<td>Z8 Xiàoxuě</td>
<td>Slight snow</td>
<td>November</td>
<td>November 22</td>
</tr>
<tr>
<td>J9 Hánlù</td>
<td>Cold dew</td>
<td>October</td>
<td>October 8</td>
</tr>
<tr>
<td>Z9 Shuāngjiàng</td>
<td>Descent of frost</td>
<td>October</td>
<td>October 24</td>
</tr>
<tr>
<td>J10 Lìdōng</td>
<td>Beginning of winter</td>
<td>November</td>
<td>November 8</td>
</tr>
<tr>
<td>Z10 Xiàoxuě</td>
<td>Slight snow</td>
<td>November</td>
<td>November 22</td>
</tr>
<tr>
<td>J11 Dàxuě</td>
<td>Great snow</td>
<td>December</td>
<td>December 7</td>
</tr>
<tr>
<td>Z11 Dōngzhì</td>
<td>December solstice</td>
<td>December</td>
<td>December 22</td>
</tr>
<tr>
<td>J12 Xiàohán</td>
<td>Slight cold</td>
<td>January</td>
<td>January 6</td>
</tr>
<tr>
<td>Z12 Dàhán</td>
<td>Great cold</td>
<td>January</td>
<td>January 20</td>
</tr>
</tbody>
</table>

### When is Qing Ming?  

*SEARCHING FOR LOVED ONES:* With four days until the Qing Ming festival, families are thronging columbaria to pay respects to those who have died. At the Nam Am Siang Theon Temple columbarium in Paya Lebar Crescent, these people were looking for the niches holding the urns of their relatives’ ashes. Qing Ming falls on the fourth day of the fourth month of the Chinese lunar calendar and is a time when the Chinese visit columbaria or cemeteries to remember the dead.
A useful rule of thumb is that Chinese New Year is the new Moon closest to the beginning of spring (立春, lìchūn). This rule is correct most of the time, but it failed in 1985 and will fail again in 2015.

Since the beginning of spring falls around Feb 4, this helps explain why Chinese New Year will always fall between Jan 21 and Feb 21. It also helps explain why Chinese New Year is called the spring festival.

In Western astronomy, spring begins at spring equinox. In Chinese astronomy, spring begins midway between winter solstice and spring equinox.
The Chinese Meridian

- Calculations are based on the meridian 120° East.
- Before 1929 the computations were based on the meridian in Beijing (116°25’), but in 1928 China adopted a standard time zone based on 120° East. This change corresponds to about 14 minutes.

1978 in Hong Kong

- Before 1978, many calendars in Hong Kong and Taiwan were still based on the old imperial calendar from 1908, the year in which the last Qīng emperor ascended the throne.
- The new Moon that marked the start of the 8th month in 1978 occurred at 16h 07m UTC on September 2. Using standard Chinese time, the new Moon occurred after midnight at 0h 07m UTC + 8 on September 3. However, using local Beijing time, as they did in Hong Kong, this was 14 minutes earlier, just before midnight at 23h 53m on September 2.
- So in Hong Kong the month started on September 2, while in China it started on September 3.
- The Mid-Autumn Festival is celebrated on the 15th day of the 8th month, so the Mid-Autumn Festival was celebrated on different days, causing a lot of confusion.
- After 1978, both Hong Kong and Taiwan have followed the same calendar as China, so at least when it comes to calendars, everybody agrees on a “one-China” policy.
The Vietnamese Calendar

- Traditionally, the Vietnamese used the Chinese calendar based on the longitude of Beijing (116°25’ East), even though the longitude of Hanoi is 105°55’ East.
- However, on August 8, 1967, the North Vietnamese government approved a new lunar calendar specifically compiled for the UTC + 7 time zone.
- The following year, the Chinese New Year new Moon occurred at 16h 29m UTC on January 29. In North Vietnam, the new Moon therefore occurred at 23h 29m UTC + 7 on Jan 29. So Chinese New Year, known as Tet in Vietnam, was celebrated on January 29 in the North.
- However, in South Vietnam, the new Moon occurred 46 minutes (11.5°) later at 0h 15m on January 30, so Tet was celebrated on January 30.

The Tet Offensive of 1968

- The North Vietnamese Army and the Vietcong guerillas were preparing for what would be known as the Tet Offensive. The instructions were to attack in the early morning of the second day of Tet.
- The units in Da Nang and other Central Vietnamese cities had closer links to North Vietnam and were aware of the calendar change, so they attacked on the morning of January 30, the day after the new Tet.
- However, in Saigon and other cities to the South, everybody was using the traditional calendar, and the attack started on the morning of January 31, the day after the traditional Tet.
The Length of a Chinese Month

- The day on which a new Moon occurs is the first day of the new month.
- The length of the months are determined astronomically. The lunar month can vary between about 29.25 and 29.75 with a mean of 29.53.
- Suppose a month is 29.5 days.

<table>
<thead>
<tr>
<th>New Moon</th>
<th>Next new Moon</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1 13h</td>
<td>May 31 1h</td>
<td>30 days</td>
</tr>
<tr>
<td>May 1 1h</td>
<td>May 30 13h</td>
<td>29 days</td>
</tr>
</tbody>
</table>

- There can be four long months or three short months in a row.

The Mid-Autumn Festival

- If the 1st month marks the beginning of spring, autumn should start with the 7th month.
- This explains why the Mid-Autumn Festival is celebrated on the 15th day of the 8th month.
The Chinese Solar Calendar

- It is important to understand that the Chinese calendar is a combination of two calendars, the usual lunisolar calendar and a solar calendar that follows the 24 jiéqì.
- The solar calendar is traditionally called the farmer’s calendar (农历). Unfortunately the term farmer’s calendar has come to include the lunisolar calendar.
- The Chinese solar calendar follows the tropical year closely, so it is perfect for farming purposes, but the lunisolar calendar is not at all suitable for farmers.

Qīngmíng (清明)

- There are two Chinese holidays that are determined by the solar calendar, namely Qīngmíng (清明) around Apr 5 and winter solstice Dōngzhì (冬至) around Dec 22.
- Notice that lunar dates can fall within a range of about one month in the solar calendar and conversely. Chinese New Year can fall between Jan 21 and Feb 21.
- Qīngmíng can fall between the 13th day of the 2nd month and the 17th day of the 3rd month.
The Chinese Year

- There are several years in the Chinese calendar. The most important are the suì (岁) and the nián (年).
- A suì is the solstice year from one winter solstice to the next. This is similar to the tropical year.
- In modern Chinese, the word suì is only used when talking about a person’s age. Traditionally, Chinese people count their age from the December solstice, but some instead count from Chinese New Year, the seventh day of the new year (人日) or from lìchūn. Using the word suì when talking about a person’s age is probably related to this custom.
- A nián is the Chinese year from one Chinese New Year to the next, which has variable length.
- Just like we can think of the Gregorian year as an approximation to the tropical year, we can think of the nián as an approximation to the suì.
- The Chinese astrological year runs from the beginning of spring (立春, lìchūn) around Feb 4, not from Chinese New Year.

The Sexagenary Cycle

The sexagenary cycle is important in the Chinese calendar.

<table>
<thead>
<tr>
<th>Heavenly Stems</th>
<th>天干</th>
<th>tiāngān</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>甲</td>
<td>jiǎ</td>
<td>Wood</td>
</tr>
<tr>
<td>2</td>
<td>乙</td>
<td>yǐ</td>
<td>Wood</td>
</tr>
<tr>
<td>3</td>
<td>丙</td>
<td>bīng</td>
<td>Fire</td>
</tr>
<tr>
<td>4</td>
<td>丁</td>
<td>dīng</td>
<td>Fire</td>
</tr>
<tr>
<td>5</td>
<td>戊</td>
<td>wù</td>
<td>Earth</td>
</tr>
<tr>
<td>6</td>
<td>己</td>
<td>jǐ</td>
<td>Earth</td>
</tr>
<tr>
<td>7</td>
<td>庚</td>
<td>gēng</td>
<td>Metal</td>
</tr>
<tr>
<td>8</td>
<td>辛</td>
<td>xīn</td>
<td>Metal</td>
</tr>
<tr>
<td>9</td>
<td>壬</td>
<td>rén</td>
<td>Water</td>
</tr>
<tr>
<td>10</td>
<td>癸</td>
<td>guī</td>
<td>Water</td>
</tr>
</tbody>
</table>
The Sexagenary Cycle 2

<table>
<thead>
<tr>
<th>Earthly Branches</th>
<th>地支</th>
<th>dìzhī</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>子</td>
<td>zǐ</td>
<td>Rat</td>
</tr>
<tr>
<td>2</td>
<td>丑</td>
<td>chǒu</td>
<td>Ox</td>
</tr>
<tr>
<td>3</td>
<td>寅</td>
<td>yín</td>
<td>Tiger</td>
</tr>
<tr>
<td>4</td>
<td>卯</td>
<td>mǎo</td>
<td>Rabbit</td>
</tr>
<tr>
<td>5</td>
<td>辰</td>
<td>chén</td>
<td>Dragon</td>
</tr>
<tr>
<td>6</td>
<td>巳</td>
<td>sì</td>
<td>Snake</td>
</tr>
<tr>
<td>7</td>
<td>午</td>
<td>wǔ</td>
<td>Horse</td>
</tr>
<tr>
<td>8</td>
<td>未</td>
<td>wèi</td>
<td>Goat</td>
</tr>
<tr>
<td>9</td>
<td>申</td>
<td>shēn</td>
<td>Monkey</td>
</tr>
<tr>
<td>10</td>
<td>酉</td>
<td>yǒu</td>
<td>Chicken</td>
</tr>
<tr>
<td>11</td>
<td>戌</td>
<td>xū</td>
<td>Dog</td>
</tr>
<tr>
<td>12</td>
<td>亥</td>
<td>hài</td>
<td>Pig</td>
</tr>
</tbody>
</table>

The Sexagenary Cycle 3

The branches are often associated with the sequence of 12 animals: rat, ox, tiger, rabbit, dragon, snake, horse, sheep, monkey, rooster, dog, and pig. It is not clear when the branches were associated with the 12 animals, but it seems to have taken place around the time of the Táng Dynasty.
The Golden Dragon

Let us denote both the stems and the branches by their numbers. We denote 1 by (1, 1) or (甲, 子), 2 by (2, 2) or (乙, 丑) and so on up to (10, 10) or (癸, 酉).

Now we have run out of stems, so we denote 11 by (1, 11) or (甲, 戌) and 12 by (2, 12) or (乙, 亥). Now we have run out of branches, too, so 13 becomes (3, 1) or (丙, 子).

We continue in this way through 6 cycles of stems and 5 cycles of branches up to 60, which is (10, 12) or (癸, 亥).

The next number is then (1, 1) or (甲, 子), which starts a new sexagenary cycle.

Notice that each branch, or animal, occurs five times in each 60-year cycle. An animal corresponding to an odd number, will meet the stems that correspond to the odd numbers.

Year 2000 is the 17th year in the current cycle (see below), so it corresponds to (7, 5) (17 = 10 + 7 = 12 + 5) or (庚, 辰). So we see that it is a metal dragon year, or a golden dragon.

The Eight Characters

The sexagenary cycle is used for keeping track of years, months, days and (double) hours in Chinese astrology. Your date and time of birth is determined by the “Eight Characters” (八字) formed by the pair of cyclical characters for the year, month, day and hour.

The 60-day cycle has been used for keeping track of days since ancient times. During the 漢 (汉) dynasty, the 60-year cycle was also introduced.
What is Year 2000 in the Chinese Calendar?

- The Chinese do not have a continuous year count. They started counting from one again with each new emperor.
- Some scholars tried to reconstruct ancient Chinese chronology by adding up years of reigns, much the same way some westerners in the past tried to reconstruct Biblical chronology.
- Some claim that the calendar was invented by the Yellow Emperor, Huángdi (黃帝), in 2637 BCE during the 61st year of his reign.
- Some people prefer to start the count with the first year of his reign in 2697 BCE.
- Since these years are 60 years apart, it follows that 1984 was the first year of either the 78th or 79th 60-year cycle. Using this as a starting point, Chinese New Year in 2000 marks the beginning of the Chinese year 4637 or 4697.
- Some people write 2636 BCE, but they really mean -2636, using the astronomical year count, where 1 BCE is year 0, 2 BCE is -1, etc.

Sun Yat-sen

- To add to the confusion, some authors use an epoch of 2698 BCE. I believe this because they want to use a year 0 as the starting point, rather than counting 2697 BCE as year 1, or that they assume that the Yellow Emperor started his year with the Winter solstice of 2698 BCE.
- In particular, this system was used by Sun Yat-sen (孫逸仙, Sūn Yìxiān or 孫中山, Sūn Zhōngshān, 1866–1925). He and other political activists wanted to use a republican and “modern” year numbering system.
- This system actually won some acceptance in the overseas Chinese community, and is for example used occasionally in San Francisco’s Chinatown. (At least around the time of Chinese New Year!)
The continuous year count is not an integral part of Chinese culture

- The continuous year count is not an integral part of the Chinese calendar, but rather an afterthought. While there isolated incidents of Chinese scholars who have used it, it only gained popularity with the Jesuit missionaries.
- Most of the people who use it are Westerners who refuse to believe that it is possible to have a “civilized” society without a continuous year count.
- While Chinese chronology is fairly reliable going back to 841 BCE, and oracle bones with date inscription go back to the 13th century BCE, modern scholars consider the Yellow Emperor to be a mythological figure.

Kāngxī (康熙)

- Beginning in the Hán dynasty, emperors would adopt era name or reign names (年号 [年號], niánhào), which together with the 60-year cycle would fix the year.
- In the past, the emperors often changed their era names during their reign, but by the time of the Míng and Qīng dynasties, the emperors used the same era name for their whole reign.
- This system worked well most of the time, but the Kāngxī Emperor (康熙) ruled more than 60 years. He ruled from February 7, 1661 to December 20, 1722. Since Chinese New Year fell on January 30 in 1661, the first year of his reign started on February 18, 1662, and the last year of his reign ended on February 4, 1723.
- Since both 1662 and 1722 are rényín years, the term Kāngxī rényín (康熙壬寅) is ambiguous.
Qiánlóng (乾隆)

This is the only such problem in Chinese history. The Qiánlóng Emperor (乾隆) ruled from October 18, 1735, to February 8, 1796. The first year of his rule started on February 12, 1736, but he chose to retire on February 8, 1796, as a filial act in order not to reign longer than his grandfather, the illustrious Kāngxī Emperor.

Despite his retirement, however, he retained ultimate power until his death in 1799.

Why Was the Calendar Important?

With a lunar or lunisolar calendar, errors are much more obvious than with a solar calendar.

A solar calendar can be off by a couple of weeks without anybody noticing. The reason why the Catholic church had to reform the Julian calendar was because the rules for computing Easter had frozen the March equinox to be March 21. That meant that Easter was drifting noticeably towards summer. Otherwise, few would have cared about the drift of the March equinox.

With a lunar calendar, an error of even a couple of days is a serious problem. Every peasant could each month see that the new Moon was visible near the end of the previous month or that the old Moon was visible in the next month.
Because of the importance the Chinese rulers placed on calendars, they were surprisingly open to incorporate foreign ideas into the making of calendars. The last three main calendar reforms have all been associated with foreign impulses.

The Main Calendar Reforms

- Before 621 BCE, the start of the month was based on visibility of the crescent Moon. During the Zhōu (周) dynasty, the Metonic cycle was used for determining leap months and the leap months were always placed at the end of the year.
- After the Tāichū (太初) calendar reform in 104 BCE, the no zhōngqì (无中气) rule was used for determining leap months, and the month containing the December solstice was fixed to be the 11th month.
- The Táng (唐) dynasty calendar reform in 619 switched to following the true Moon. This was inspired by Indian Buddhist astronomers.
- The Yuán (元) dynasty reform in 1280 was inspired by Muslim astronomers. It was the most accurate calendar in the world at that time.
- The last calendar reform came in 1645 during the Qīng dynasty (清) and was implemented by Jesuit missionaries. It used the true Sun.
The Jesuits

► In 1644, the German Adam Schall (汤若望 [汤若望], Tāng Ruòwàng, 1592-1666) went to the new Qīng rulers and presented his calculations for an upcoming solar eclipse.

► He challenged the Chinese and the Muslim astronomers in the Imperial Astronomical Bureau (欽天監, Qìntiānjiān), and the Jesuits' calculations were best.

► Schall was appointed director of the Bureau. The next year, he formulated the current rules for the Chinese calendar.

The Trial of the Jesuits

► A Chinese official, Yáng Guāngxiān (杨光先), had as his slogan that it was “better to have a wrong calendar than to have foreigners in China”. Yang managed to have the Jesuits arrested in 1664.

► A solar eclipse was coming up and while in prison, the Jesuits predicted it would occur at 3 p.m., Yang predicted 2:15 p.m., and the Muslim Wú Míngxuǎn (吴明炫) predicted 2:30 p.m.

► On the day of the eclipse, the Jesuits were brought into the palace in chains, and everybody watched as the eclipse occurred at 3p.m. sharp!

► Unfortunately, the regents were not impressed and the Jesuits were sentenced to death.

► However, the next day a strong earthquake struck Beijing. This was taken as a sign from Heaven that the sentence was unjust, and the sentence of the Jesuits was first converted to flogging and eventually to just house arrest.
In 1668, the Kangxi (康熙) emperor took over from the regents. The emperor ordered the Belgian Ferdinand Verbiest (南怀仁 [南懷仁], Nán Huáirén, 1623-1688), Yáng and Wú to compute the length of the shadow of a pole on a certain day and the position of the Sun at noon on a certain day.

They were to leave their instruments pointing towards the predicted spot in the emperor’s garden two weeks in advance. Verbiest easily won and was appointed director of the Bureau, while Yáng and Wú were arrested.

Verbiest became personal tutor to the Kangxi emperor, and even learned Manchu. Jesuits remained as directors of the Bureau until 1746 and it was run by other Westerners until 1826.